CHAPTER 9

OVERLAY PAVEMENTS

9-1. General. Normally, overlays of existing pavements are used for two reasons: (a) to increase the load-carrying capacity of an existing pavement, or (b) to correct a defective surface condition on the existing pavement. Of these reasons, the first requires a structural design procedure for determining the thickness of overlay, whereas the second requires only a thickness of overlay sufficient to correct the surface condition, and no increase in load-carrying capacity is considered. The design method for overlays included herein is to determine the thickness required to increase load-carrying capacity.

9-2. Definitions and symbols for overlay pavement design. The following terms and symbols apply to the design of overlay pavements and are defined for the purpose of clarity.

a. Definitions.

(1) Rigid base pavement - Existing pavement to be overlaid and is composed of portland cement concrete.

(2) Flexible base pavement - Existing pavement to be overlaid and is composed of bituminous concrete, base, and subbase courses.

(3) Composite pavement - Existing pavement to be overlaid and is composed of an all-bituminous or flexible overlay on a rigid base pavement.

(4) Overlay pavement - A rigid or nonrigid pavement constructed on an existing base pavement to increase load-carrying capacity.

(5) Rigid overlay - An overlay pavement and is composed of portland cement concrete.

(6) Nonrigid overlay - An overlay pavement and is composed of all-bituminous concrete or a combination of bituminous concrete, base, and subbase courses.

(7) All-bituminous overlay - A nonrigid overlay composed of bituminous concrete for the full depth.

(8) Flexible overlay - A nonrigid overlay composed of bituminous concrete surface and granular base and subbase courses.

b. Symbols. The following symbols are used.

(1) k Modulus of subgrade reaction, lb/in^3.

(2) CBR California bearing ratio.

(3) R Concrete flexural strength, lb/in^2.

(4) h Existing rigid pavement thickness, inches.

(5) h_o Rigid overlay thickness, inches.

(6) t Nonrigid overlay thickness, inches.

(7) C Coefficient depending upon structural condition of rigid base pavement.

(8) h_d Exact thickness of rigid pavement that would be required if placed directly on the foundation. h_d is determined from figure 5-1 using the modulus of subgrade reaction, k. For rigid overlays, the flexural strength, R, will be the 28-day strength of the overlay. For nonrigid overlays, the flexural strength to be used for the determination of h_d will be that of the rigid base pavement.

(9) t_d Exact thickness of flexible pavement that would be required if placed directly on the subgrade. The thickness is determined from design procedures presented in EM 1110-3-131.

9-3. Preparation of existing pavement. Inspections of the existing pavement should be made to locate all areas of distress in the existing pavement and to determine the cause of the distress. Areas showing extensive and progressive cracking and/or foundation failures should be removed and repaired prior to the overlay. This is especially true of areas where excessive pumping, bleeding of water at joints or cracks, excessive settlement in foundation, subgrade rutting, slides, etc., have occurred. If voids are detected beneath the base pavement, they should be filled by grouting prior to the overlay. The surface of the existing pavement should be conditioned for the various types of overlay as follows:

a. Rigid overlay. The surface of the existing base pavement should be cleaned of all foreign matter, spalled concrete, extruded joint seal, bituminous patches, and other materials that would prevent the overlay from bonding to the base pavement.

b. Flexible overlay. No special conditioning of the existing surface is required other than the removal of debris and loose aggregate and/or concrete.

c. All-bituminous overlay. The surface of the existing pavement will be cleaned of all foreign matter, fat spots in existing bituminous patches, spalled concrete, and extruded joint seal. When the joints, cracks, or spalled areas in the existing pavement are wide enough, a hot sand-asphalt mixture should be used to fill them to the grade of

the existing pavement. Wedge courses of bituminous concrete should be used to bring the existing pavement to proper grade when necessary. Prior to placement of the all-bituminous overlay, a tack coat should be applied to the existing pavement surface.

9-4. Rigid overlay of rigid base pavements. The criteria contained in paragraph 1-5 are applicable to the design of rigid overlays. The placement of forms and the determination of thickness for the rigid overlay should be as follows:

a. Placing forms. If it is necessary to drill holes in the existing rigid pavement to provide anchorage for the overlay pavement forms, the size of the holes and the number drilled should be the minimum that will adequately accomplish the purpose. The holes should not be located close to joints or cracks where they might induce spalling, and they should be spaced or staggered so as to minimize additional cracking.

b. Determination of overlay thickness. The thickness of rigid pavement overlay necessary to increase the load-carrying ability of an existing rigid base pavement should be determined by one of the following equations:

$$h_o = \sqrt[1.4]{h_d^{1.4} - Ch^{1.4}} \qquad \text{(eq 9-1)}$$

Equation 9-1 is for the condition of partial bond developing between the rigid overlay and rigid base pavement. It should be used to determine the overlay thickness when no bond-breaking medium is used, such as a tack coat, sand-asphalt patch, or leveling course, etc.

$$h_o = \sqrt{h_d^2 - Ch^2} \qquad \text{(eq 9-2)}$$

Equation 9-2 is for the condition of no bond developing between the rigid overlay and rigid base pavement. It should be used to determine the overlay thickness when a sand-asphalt leveling course, bituminous patch, or tack coat, etc., is used on the surface of the existing base pavement. The coefficient C is determined by the structural condition of the rigid base pavement. Its numerical value should be established as follows, based upon a visual inspection of the existing pavement.

C = 1.00 when the slabs are in good condition, with little or no structural cracking.

C = 0.75 when the slabs show initial cracking due to loading, but little or no multiple cracking.

C = 0.50 when a larger number of slabs show multiple cracking, but the majority of slabs are intact or contain only single cracks.

C = 0.35 when the majority of slabs show multiple cracking.

In both of the equations, h_d is the exact thickness, to the nearest tenth of an inch, of monolithic rigid pavement that would be required for the design traffic conditions, and is determined from figure 5-1. The design thickness of all overlay slabs should be in multiples of 1 full inch. Whenever the calculations show a fractional inch thickness greater than one-quarter, the next full inch thickness should be used. The minimum rigid overlay pavement thickness should be 6 inches unless it is reinforced or bonded to the rigid base pavement, as described in the following paragraphs.

c. Joints. Unless a bond-breaking medium is used between the rigid overlay and rigid base pavement, or the rigid overlay is reinforced, joints should be provided in the overlay which coincide with all joints in the base pavement. However, it is not necessary that the joints in the overlay be of the same type as those in the existing base pavement. When an appreciable thickness of bond-breaking medium is used, 1/4 inch or more, the matching of joints in the overlay and base pavement is not necessary but is advisable.

9-5. Reinforced rigid overlay of rigid base pavements. Reinforced rigid overlays of existing rigid pavements should be used only when they prove to be more economical, when it is necessary to reduce the thickness of the overlay to meet grade requirements, or for other reasons where it is impractical or impossible to provide the required strengthening by means of a nonreinforced rigid overlay. The thickness of nonreinforced rigid overlay should be determined in accordance with paragraph 9-4, and the percentage of steel and thickness reduction should be determined in accordance with chapter 6 of this manual. When reinforced rigid overlays are used, the minimum thickness of overlay should be 4 inches. It is not necessary to provide joints in the reinforced rigid overlay which coincide with all joints in the base pavement; however, when a joint is required in the overlay, it should coincide with a joint in the base pavement.

9-6. Rigid overlays of flexible base and composite base pavements.

a. Flexible base pavements. A rigid overlay of an existing flexible pavement should be designed in the same manner as a rigid pavement on grade, in accordance with chapter 5. A modulus of subgrade reaction, k, should be determined by a plate-bearing test made on the surface of the existing flexible pavement. If not practicable to determine k from a plate-bearing test, conservative value may be estimated from figure 2-1 by comparing the existing flexible pavement

with a well-packed gravel or consolidated clay. The following limitations, however, should apply:

- In no case should a k value greater than 500 lb/in^3 be used.

- The plate-bearing test to determine the k value should be performed on the flexible pavement at a time when the temperature of the bituminous concrete is of the same order as the ambient temperature of the hottest period of the year in the locality of the proposed construction.

b. Composite base pavements. Two conditions of composite pavement can be encountered when considering a rigid overlay. When the composite pavement is composed of a rigid base pavement with less than 4 inches of all-bituminous overlay, the required thickness of rigid overlay should be determined using the no-bond overlay equation 9-2. If the composite pavement is composed of a rigid base pavement with 4 inches or more of either all-bituminous or flexible overlay, the required thickness of rigid overlay should be determined in accordance with paragraph 9-6.a.

9-7. Nonrigid overlay of rigid base pavements.

a. Design procedure. The design procedure presented herein determines the thickness of nonrigid-type overlay necessary to increase the load-carrying capacity of existing rigid pavement. This method is limited to the design of the two types of nonrigid overlay defined in paragraph 9-2. The selection of the type of nonrigid overlay to be used for a given condition is dependent only on the required thickness of the overlay. Normally, the flexible overlay should be used when the required thickness of overlay is sufficient to incorporate a minimum 4-inch compacted layer of high-quality base-course material plus the required thickness of bituminous concrete surface courses. For lesser thicknesses of nonrigid overlay, the all-bituminous overlay should be used. The method of design is referenced to the deficiency in thickness of the existing rigid base pavement and assumes that a controlled degree of cracking will take place in the rigid base pavement during the design life of the pavement.

b. Determination of overlay thickness. The thickness of nonrigid overlay (all-bituminous or flexible) required to increase the load carrying capacity of an existing rigid base pavement to a designated level should be determined by the following equation:

$$t = 2.5(Fh_d - Ch)$$

where h_d is the exact thickness (to the nearest 1/10 inch) determined from figure 5-1 using the flexural strength of the existing rigid base pavement, the measured or estimated subgrade modulus, k, and the appropriate rigid-pavement design index. The factor F will be: .1 for a design index = 1; .7 for a design index = 2; .9 for a design index =

3; and .95 for design indices 4 through 10. The C factor is a coefficient depending on the structural condition of the existing rigid base pavement. Numerical values of C are determined as follows:

C = 1.00 when rigid base pavement slabs contain only nominal initial cracking.

C = 0.75 when the rigid base pavement slabs contain multiple cracks and numerous corner breaks.

The overlay thickness, t, used in design should be determined to the nearest 1 inch.

c. All-bituminous overlay. The all-bituminous overlay is required only when the combined thickness of a minimum 4-inch compacted base course and the required thickness of bituminous surface course exceeds the design thickness, t. There is no limitation, other than the economics of construction, on the maximum thickness of all-bituminous overlay that can be used. The bituminous concrete overlay should be designed in accordance with the requirements of EM 1110-3-131. A tack coat is required between the rigid base pavement and the all-bituminous overlay. A minimum thickness of 2 inches will be required for an all-bituminous overlay designed to increase the structural capacity of a base pavement. No limitation is placed on the minimum thickness of an all-bituminous overlay when used as a maintenance measure to improve pavement surface smoothness.

d. Flexible overlay. A flexible overlay (bituminous surface course and granular base course) may be used when the design thickness, t, is large enough to permit the use of a 4-inch compacted base course plus the required thickness of bituminous surface course. The required thickness of bituminous surface course and the design of the surface course should be in accordance with EM 1110-3-131. The base-course material should be a crushed aggregate material exhibiting a CBR of 100 for the full depth. The gradation and compaction requirements of the base course should be determined from EM 1110-3-131.

9-8. Overlays in frost regions. Whenever the subgrade is susceptible to differential heaving or weakening during the frost-melt period, the overlay design should meet the requirements for frost action as given in EM 1110-3-138. When it is determined that distress in an existing pavement has been caused by differential heaving due to frost action, an overlay may not correct the condition unless the combined thickness of the pavement is sufficient to prevent substantial frost penetration into the underlying frost-susceptible material.